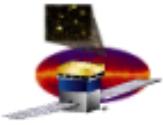


# GLAST Large Area Telescope: LAT Technical Status and Schedule

Lowell A. Klaisner  
Stanford Linear Accelerator Center  
LAT Instrument Project Manager

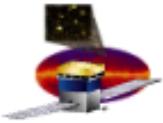
Klaisner@slac.stanford.edu  
650-926-2726



# Outline – Transition from Design to Flight Hardware

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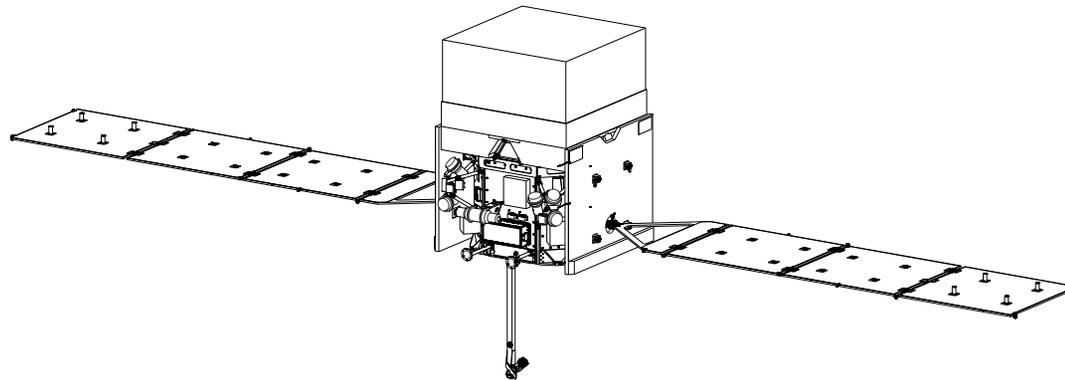
- **Introduction**
- **Organization**
- **Rebaseline**
- **Schedule**
- **Subsystem status**
- **Project issues**
- **Summary**



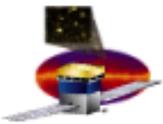
## GLAST MISSION SUMMARY

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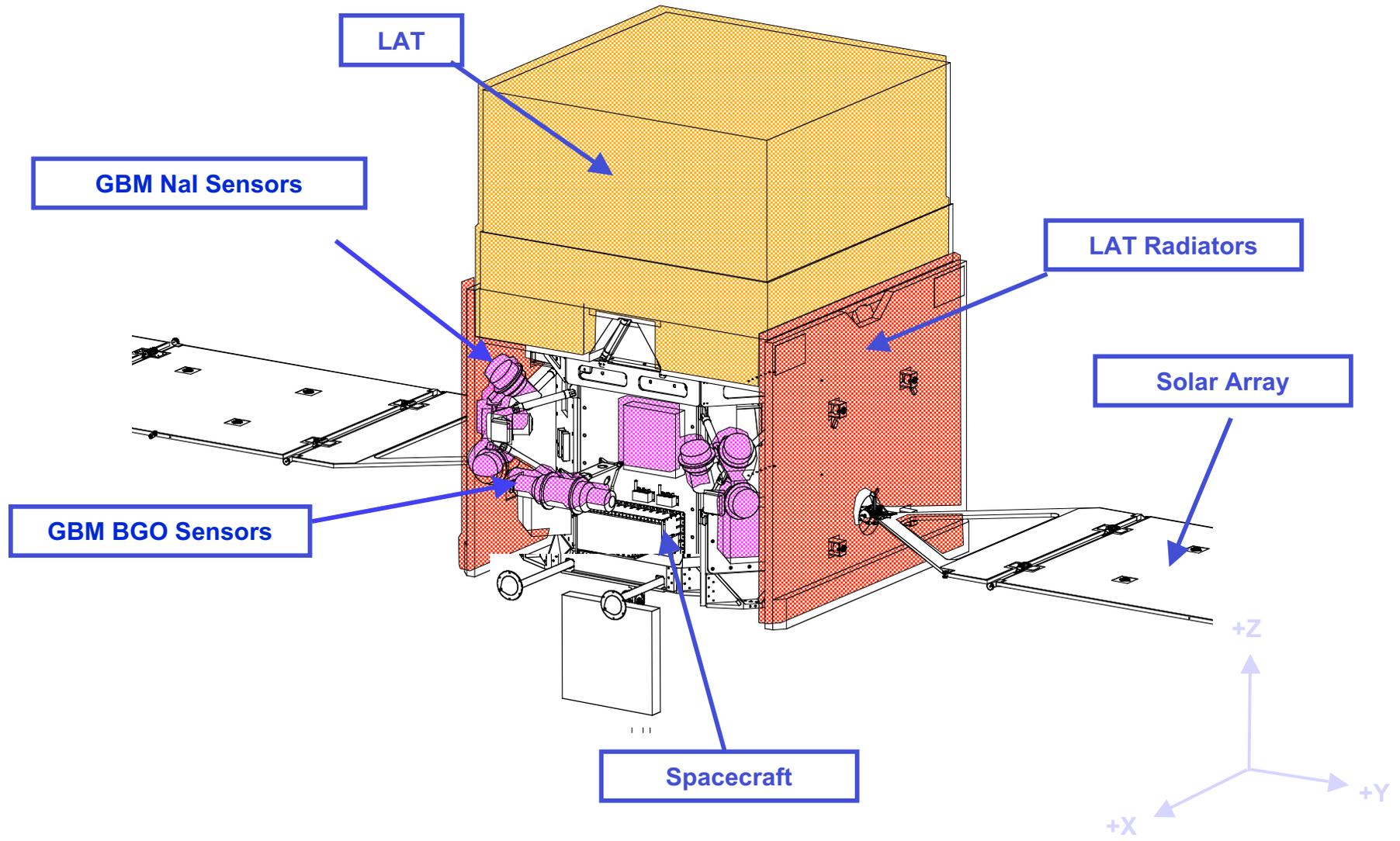
•**Objective:** Larger field of view (FOV), higher sensitivity, and broader energy detection range than any previously flown gamma-ray mission.

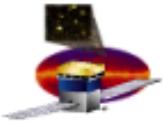


- Mission Duration:** 5 yrs (10 yr Goal)
- Orbit:** 565 km Circular, 28.5° Inclination
- Launch Date:** December 2006
- Launch Vehicle:** Delta 2920H-10
- Launch Site:** Kennedy Space Center



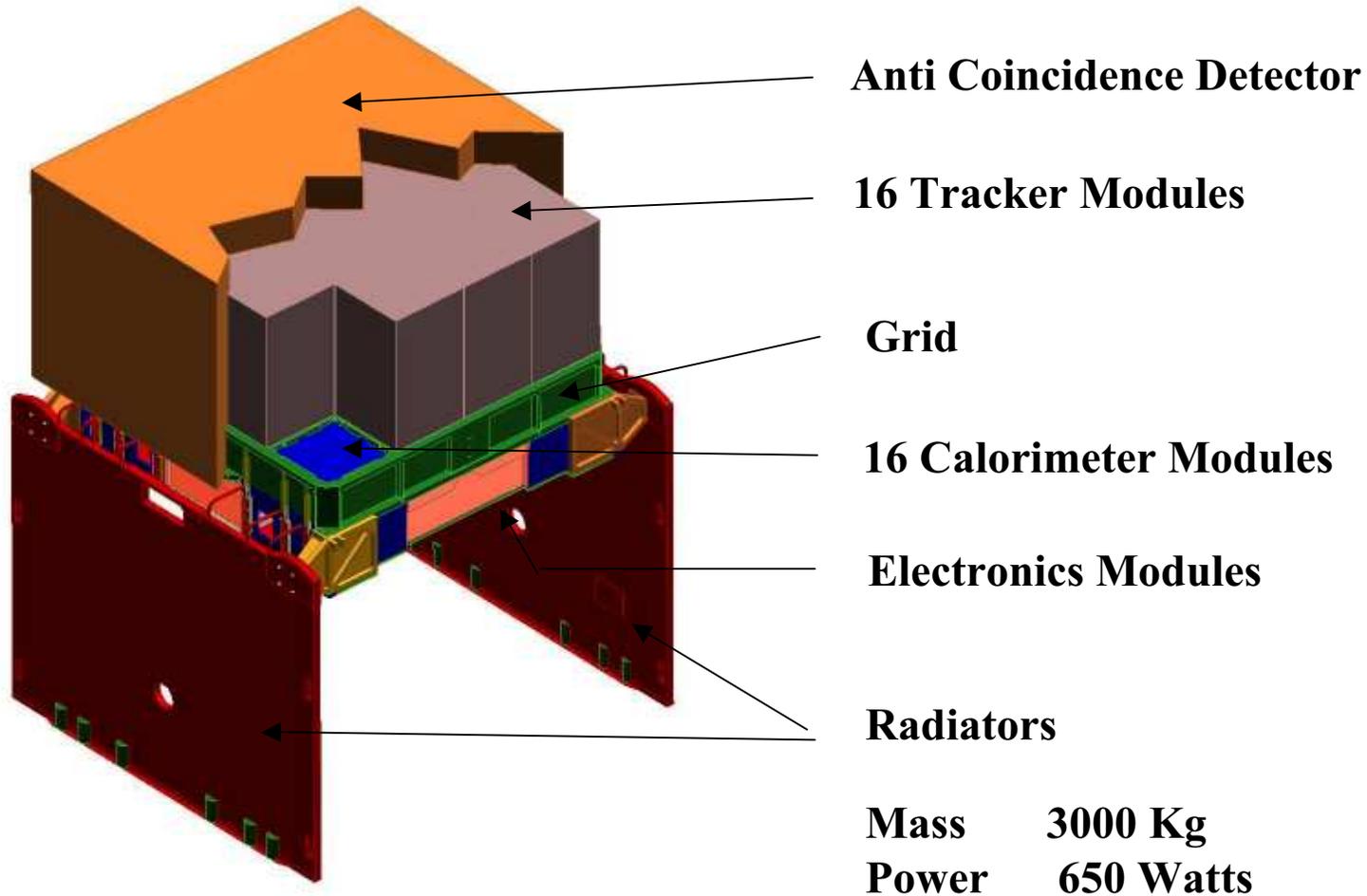
# GLAST Observatory

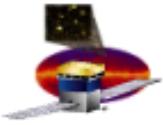




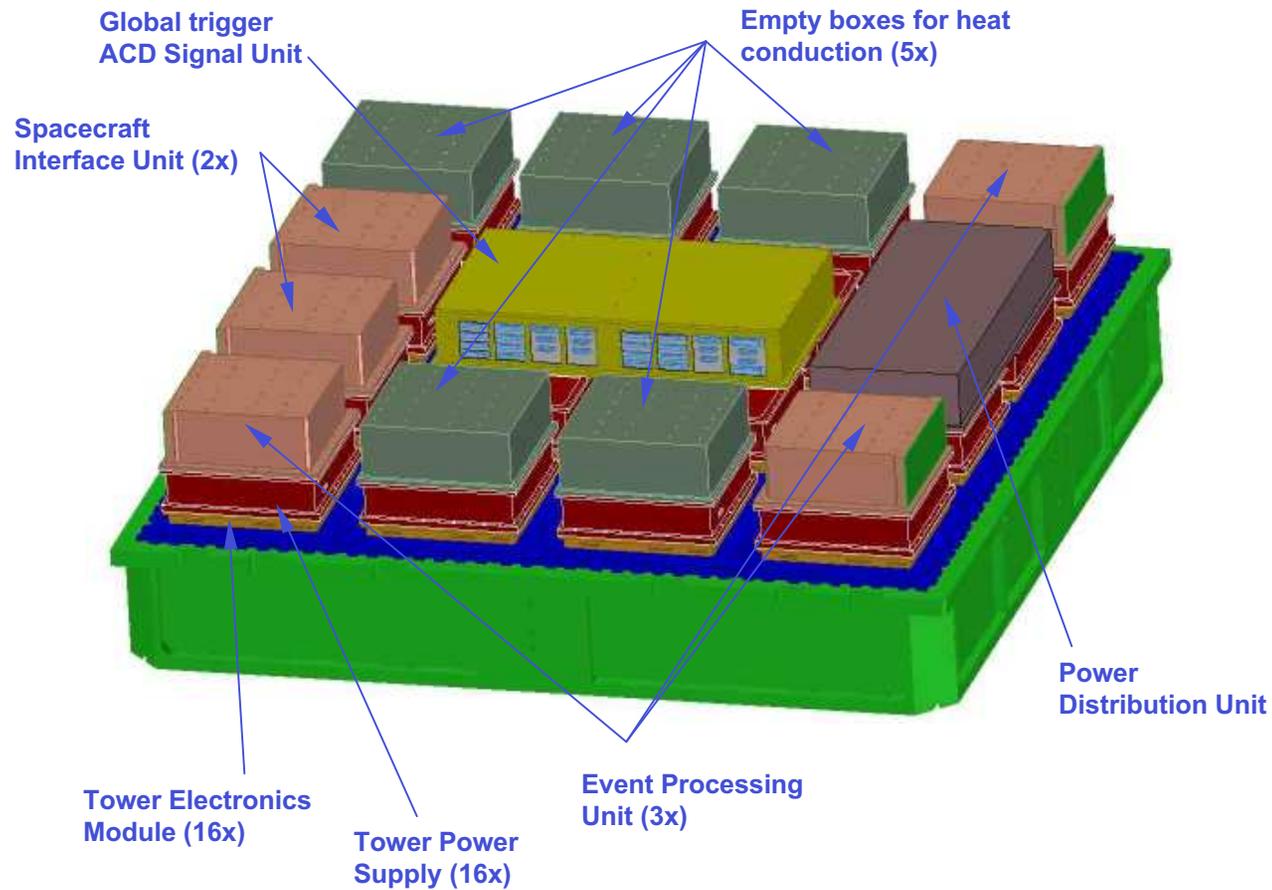
# Instrument Structure

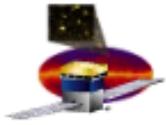
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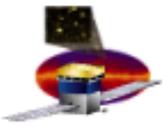


# LAT Underside Structure

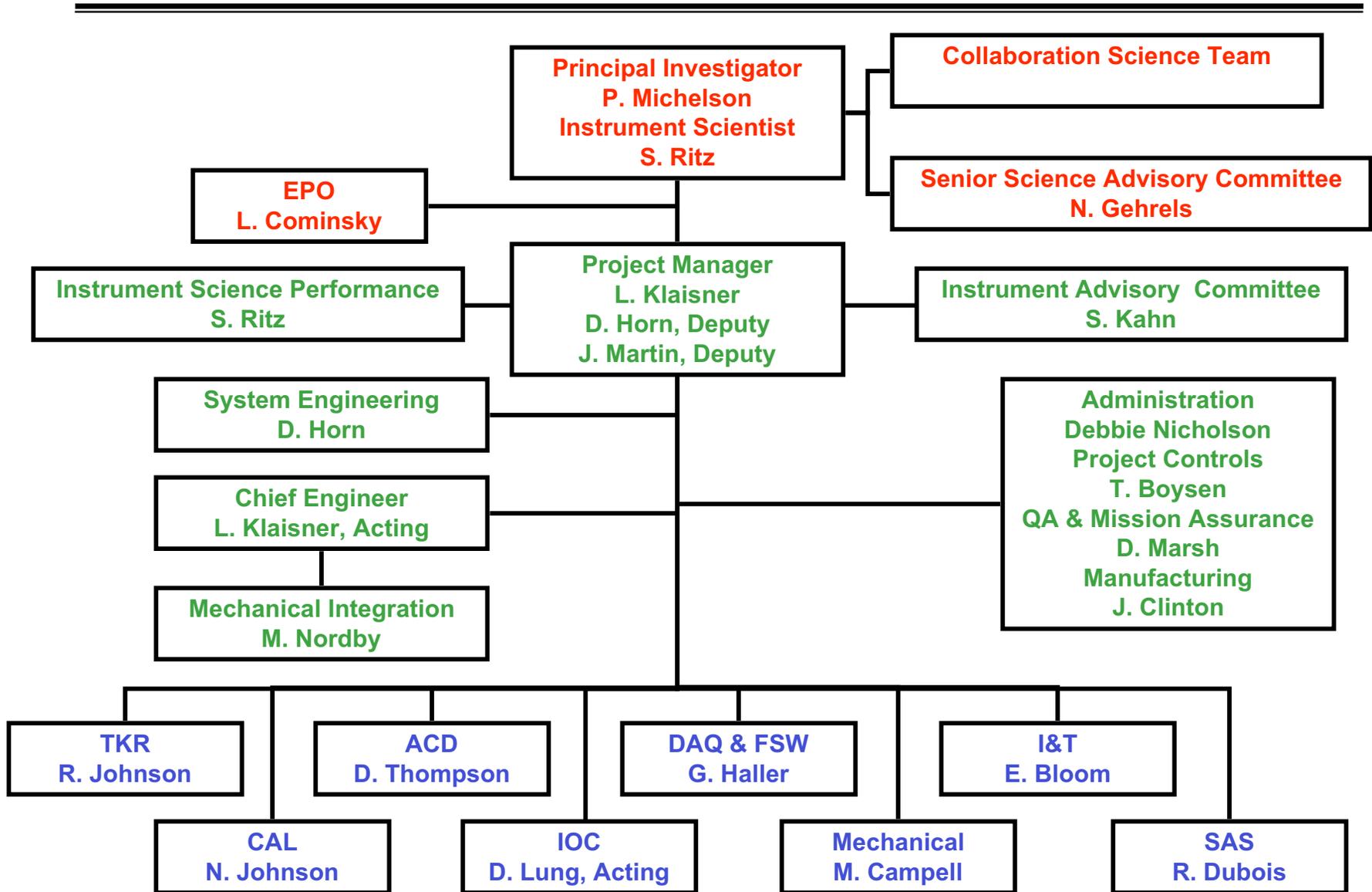


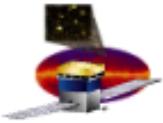


# Organization

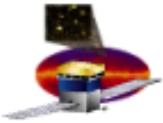


# LAT Organization Chart





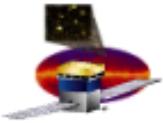
## Rebaseline (US Funds)



# Rebaseline Overview

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- **Motivation for reviewing cost and schedule**
  - **CNES in France deciding to not fund LAT work**
  - **Completion of CDR/CD-3 Review**
    - **Design is mature**
    - **Construction of flight hardware beginning**
- **Approved increased**
  - **LAT Funding increased by \$17.2 million**
    - **Fabrication Phase (LAT construction project) increased by \$11.7 million**
    - **Commissioning Phase increased by \$5.5 million**
  - **3 Month extension**

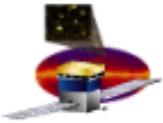


# Additions to budgets

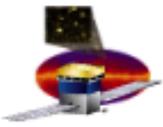
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Fabricate CDEs using US funds	\$4.2
Tracker	\$1.5
Anti-Coincidence Detector	\$0.9
Electronics manufacturing costs	\$0.8
Mechanical design / fabrication	\$2.0
Schedule delay ("standing army")	\$5.4
Increase in contingency	\$2.4
<b>Total</b>	<b>\$17.2</b>

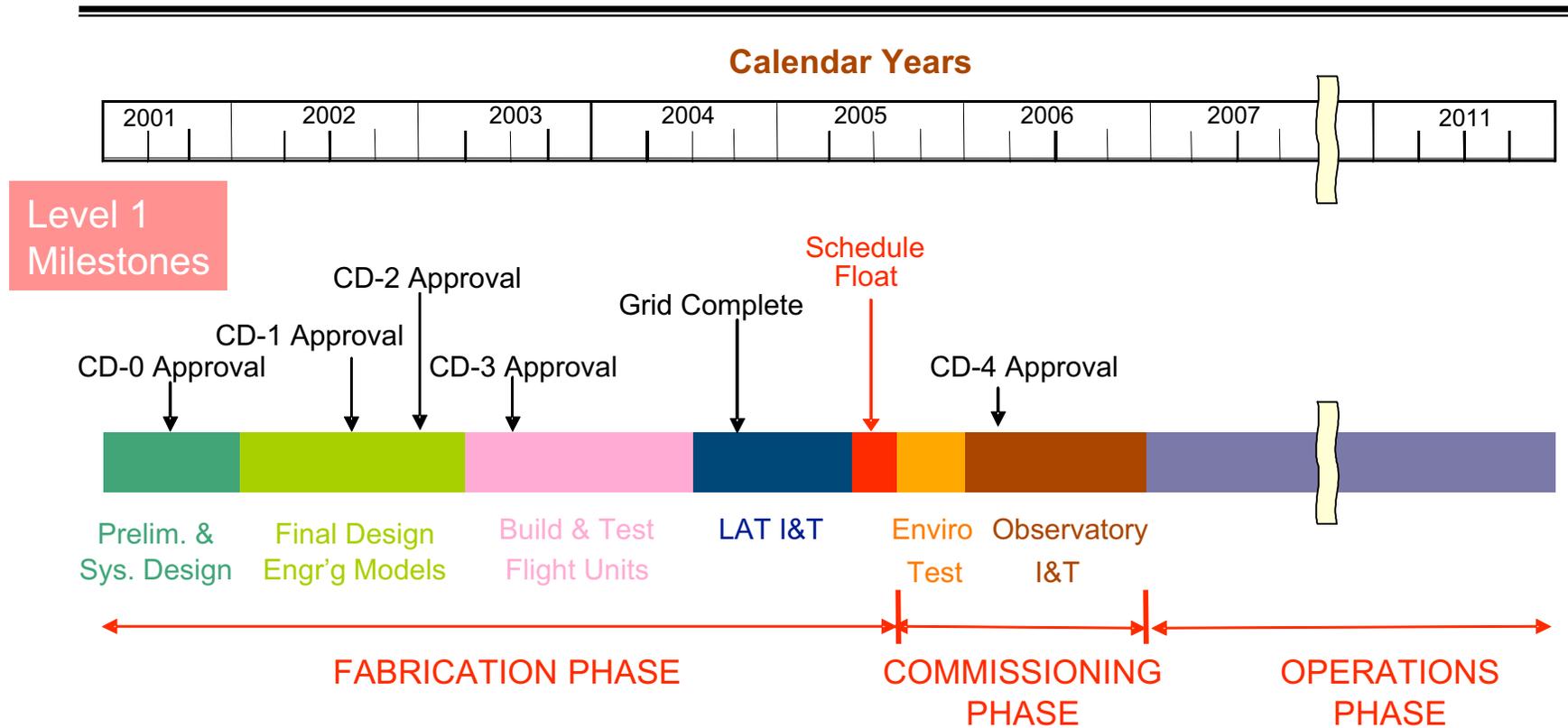
All values in millions of dollars



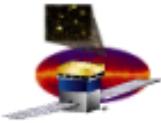
# Schedule



# Overall Schedule



GLAST planned for launch in December 2006 TBR

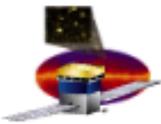


# Level 1 and 2 Milestones

	Existing	Proposed
<b>Level 1 Milestones -- DOE/NASA Joint Oversight Group</b>		
DOE Critical Decision (CD) 0 Approval	June 25, 2001	June 25, 2001 Actual
CD-1 Approval	July 1, 2002	July 23, 2002 Actual
CD-2 Approval	December 13, 2002	November 8, 2002 Actual
CD-3 Approval	July 15, 2003	September 3, 2003 Actual
Flight Grid Complete	September 15, 2004	September 15, 2004
CD-4 Approval	March 15, 2006	March 15, 2006
<b>Level 2 Milestones -- Federal Project Managers</b>		
Launch Balloon Flight	August 1, 2001	August 1, 2001 Actual
Instrument Preliminary Design Review	January 8, 2002	January 8, 2002 Actual
Instrument Critical Design Review	April 30, 2003	May 16, 2003 Actual
TKR, CAL, FMA,B Available for Calibration Ur	February 17, 2004	<b>See Note</b>
Start LAT Integration	June 15, 2004	<b>August 24, 2004</b>
Pre-Environmental Test Review	February 15, 2005	<b>July 14, 2005</b>
Instrument Pre-Ship Review (PSR)	July 7, 2005	<b>December 1, 2005</b>

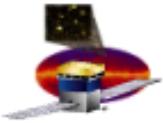
Note: The calibration test has been moved until after LAT integration. Units FM A and B or the TKR and CAL will be installed in the Grid for the start of integration

**Proposed changes in Blue**



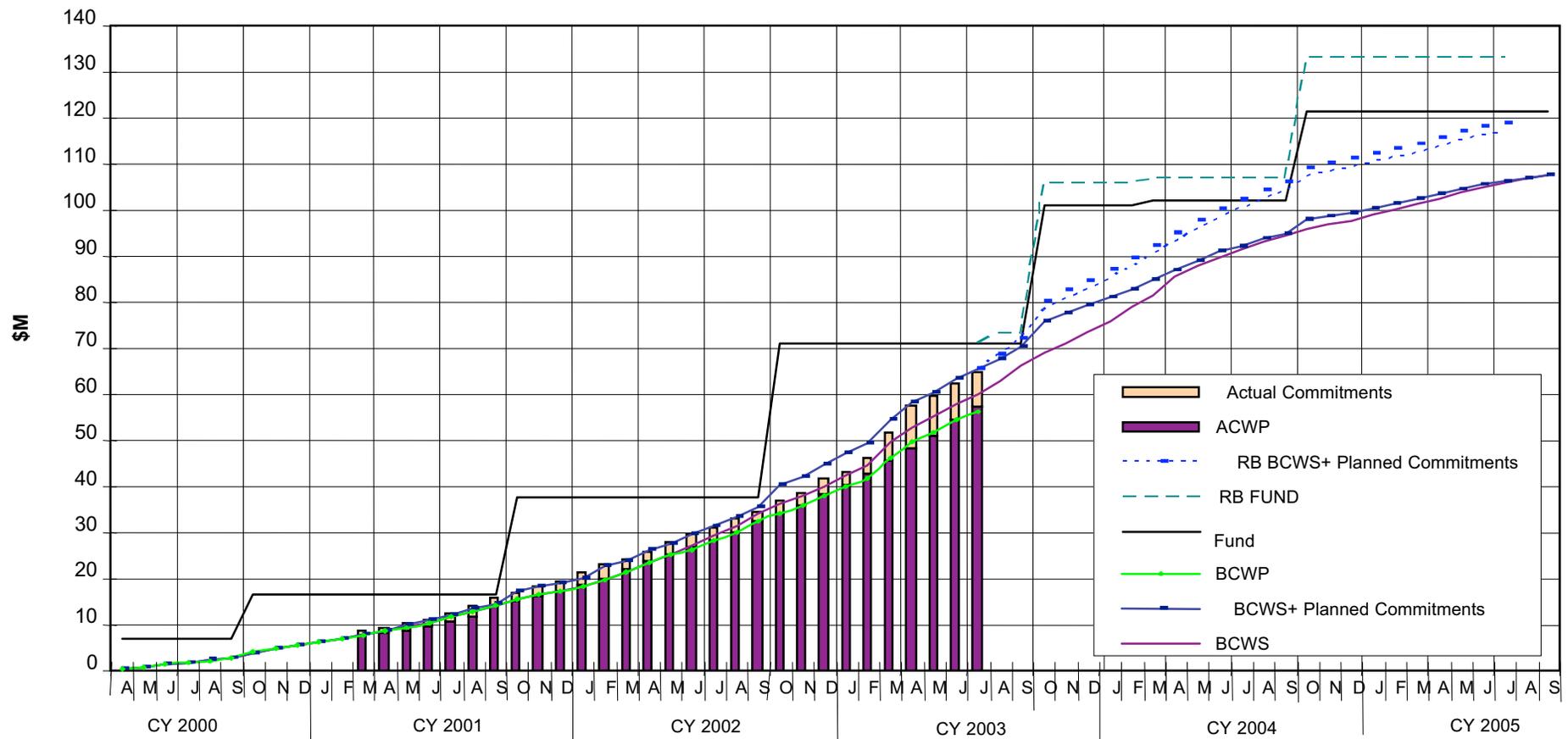
# Planned dates and Milestones

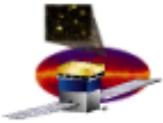
					CY 2004												CY 2005											
					J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
<b>Tracker</b>	Planned	5/20/04	10/21/04																									
	Milestones	7/14/04	12/17/04	8																								
<b>Calorimeter</b>	Planned	5/20/04	10/21/04																									
	Milestones	7/14/04	12/17/04	8																								
<b>TEM/TEMPS</b>	Planned	5/20/04	10/21/04																									
	Milestones	7/14/04	12/17/04	8																								
<b>GRID Assembly</b>	Planned		5/20/04																									
	Milestones		7/14/04	8																								
<b>Install Towers</b>	Planned	5/20/04	11/11/04																									
	Milestones	7/14/04	12/31/04	7																								
<b>Anti-coincidence Detector</b>	Planned		9/21/04																									
	Milestones		12/17/04	12																								
<b>Data Acquisition</b>	Planned		9/10/04																									
	Milestones		12/17/04	14																								
<b>X-LAT Plate</b>	Planned		8/2/04																									
	Milestones		12/17/04	20																								
					<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="text-align: center;"> <p><b>Begin</b>      <b>End</b></p> <p>Planned early delivery dates <span style="color: green;">█</span></p> <p>Milestone dates <span style="color: red;">█</span></p> <p>Explicit float imbeded in the plan <span style="color: blue;">█</span></p> </div> <div style="text-align: center;"> <p>*FLT = weeks between planned completion and milestone</p> </div> </div>																							
<b>Install Global Items</b>	Planned	12/9/04	1/20/05																									
	Milestones	1/1/05	4/7/05	11																								
<b>System Test</b>	Planned	1/20/05	4/28/05																									
	Milestones	4/7/05	7/14/05	11																								
<b>Pre-envir. Test Review</b>	Planned		4/28/05																									
	Milestones		7/14/05	11																								
<b>Environmental Test</b>	Planned	7/14/05	11/3/05																									
	Milestones	7/14/05	12/1/05	4																								
<b>Pre-ship Review</b>	Planned		11/3/05																									
	Milestones		12/1/05	4																								



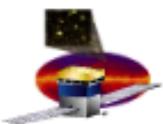
# LAT Rebaseline for US Funds

Budget vs Actuals vs Performance  
DOE + NASA Project Expenditures  
4.1 LAT

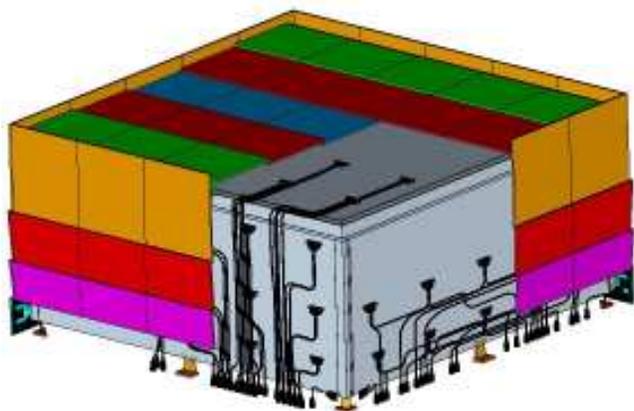




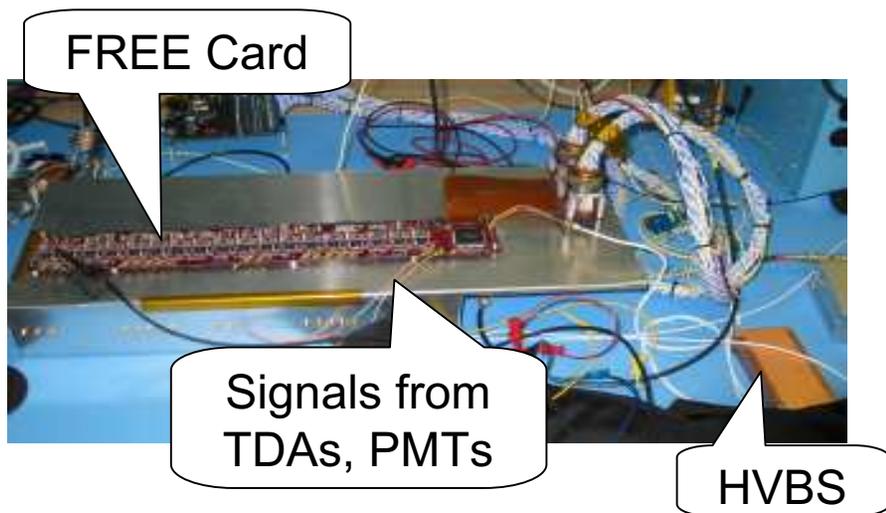
# Subsystem Status

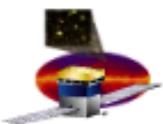


# ACD Status

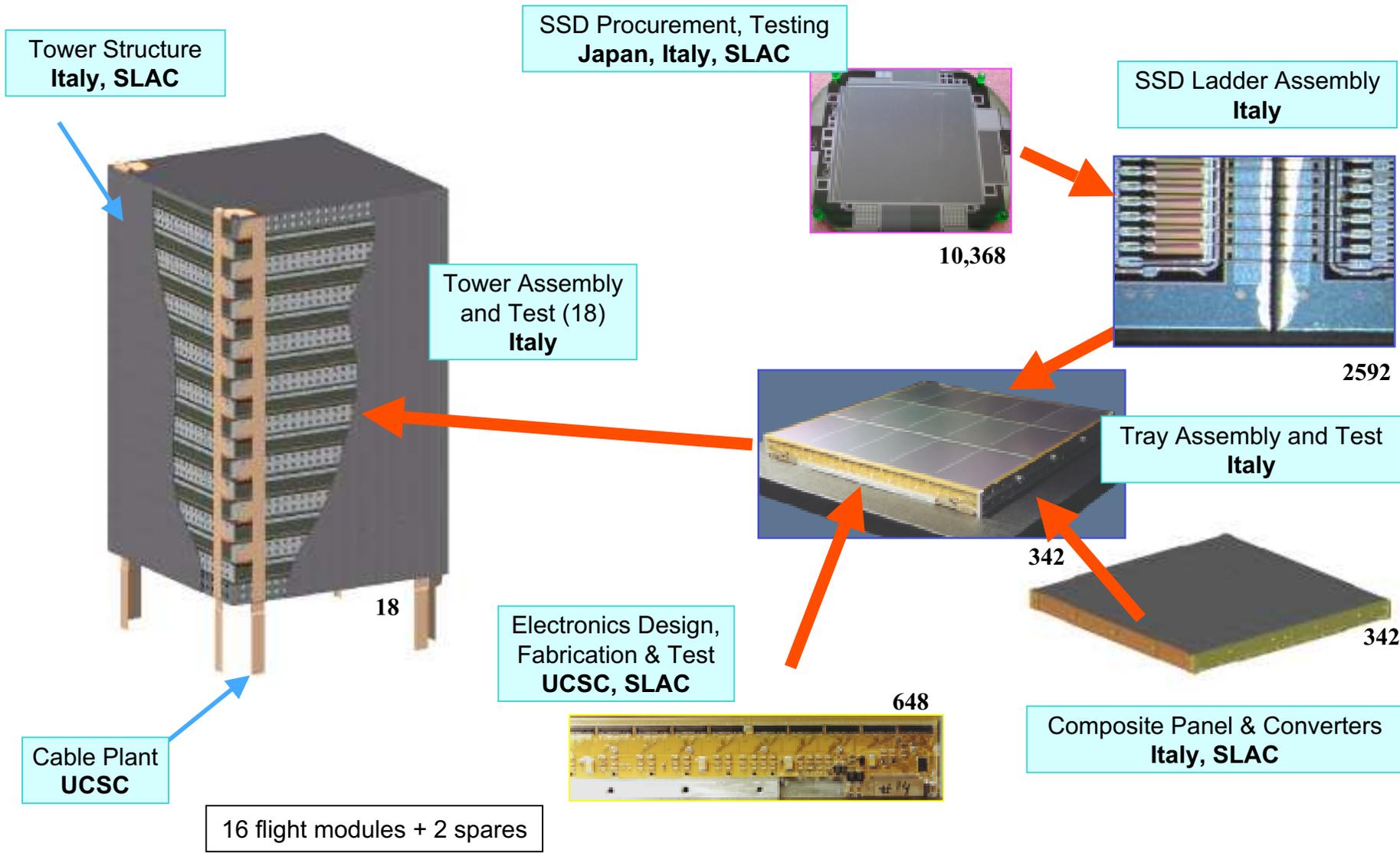


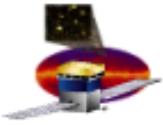
- ACD design is essentially complete
  - Some mechanical interference issues are being resolved
- Detector/Electronics End-to-End testing
  - Required performance confirmed with flight-type scintillator Tile Detector Assembly (TDA), phototubes (PMT), High Voltage Bias Supply (HVBS), Front End Electronics (FREE) card
- Fabrication of mechanical structure is underway
  - Composite shell and aluminum base frame are in fabrication





# Tracker

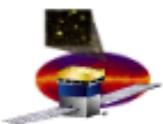




# Tracker Status

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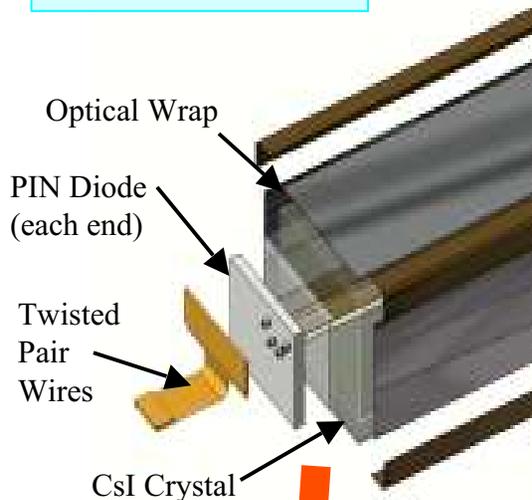
- **First Flight Tower forecast for 19 April 2004**
- **Ladder production has begun**
  - **Tooling performs well – excellent alignment results**
  - **>600 manufactured so far**
  - **>450 tested, excellent yield**
- **MCMs**
  - **In test on the LAT EM and the DAQ test bed**
  - **Preproduction of 50 flight MCMs**
- **ASICs**
  - **Flight run complete**
  - **75% tested so far – yield is well above 90%, enough for spares**



# Calorimeter

CsI Crystals  
Sweden (KTH)

CDE Assembly  
NRL



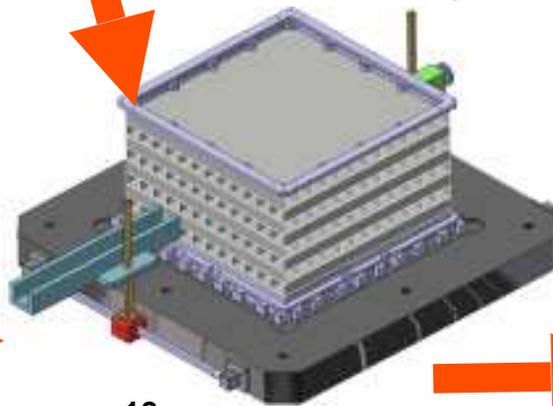
1728

16 flight modules + 2 spares

Mechanical Structure  
France (IN2P3/Ecole Polytechnique)



18



18

PEM Assembly  
NRL

Front-End Electronics  
NRL, SLAC

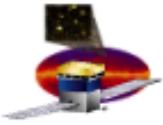
72



18

Module Assembly  
and Test, NRL+collab

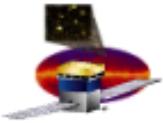




## Status - Loss of CNES Support in France

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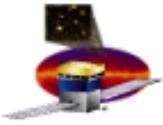
- In April, CNES (the French Space Agency) announced their withdrawal from planned commitments to the French contributions to GLAST
- As a consequence, CEA and IN2P3 were forced to reduce their hardware contributions to CAL.
  - Purchase of PIN photodiodes and the manufacture of CDEs was transferred from CEA to NRL.
  - The machining of aluminum and titanium parts of the CAL structure were transferred from IN2P3 to NRL.
  - Manufacture of composite structure will continue with IN2P3.
- The cost and schedule impact of this change was presented to the LAT International Finance Committee and the US sponsors.
  - The revised program and responsibilities have been approved and we are in the process of re-baselining the LAT cost and schedule.



# CAL Status

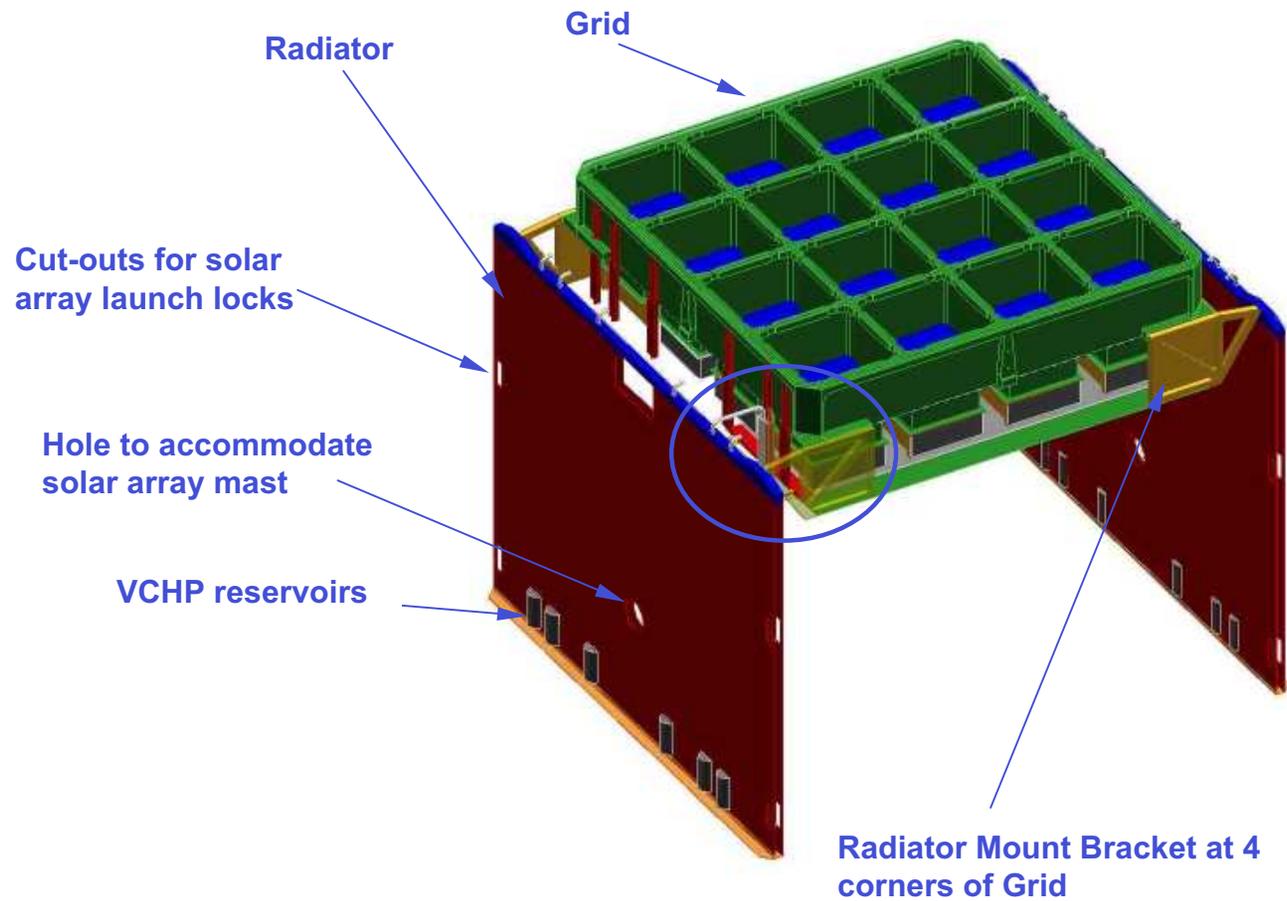
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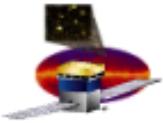
- **CAL Subsystem successfully completed Peer Design Review (Mar ,03) and LAT Critical Design Review (May ,03).**
- **Engineering Model CAL assembly was completed in March.**
- **Environmental testing of EM CAL was completed in July.**
  - **Qualification level vibration tests**
  - **Qualification temperature Thermal Vac – 8 cycles.**
  - **EMI/EMC testing**
- **EM CAL was shipped to SLAC for Integration and Test activities in August.**
- **Design revisions for flight production are essentially complete**
  - **Modified carbon composite structure manufacturing technique**
  - **Modified PIN Diode optical window**
  - **New GCFE (analog ASIC) version**
  - **Modified CAL base plate to accommodate new CAL-GRID interface requirements.**
- **Delivery of flight components is well underway**



# Mechanical and Thermal

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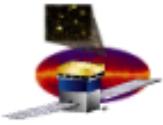




## Mechanical - Status

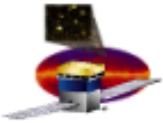
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- **GRID**
  - **1X4 version for EM delivered to SLAC in August**
    - **Currently under test**
    - **Ready for I&T in September**
  - **Cal-GRID – detailed design being finalized now**
  - **X-LAT to Electronics boxes –detailed design completed in September**
  - **4X4 on schedule for delivery to I&T in April 2004**
    - **Contract let to Tapemation – the same company that did the 1X4**
    - **Detailed stress analysis underway**
    - **Design Review planning underway**
    - **MRR scheduled for September**
    - **1st Aluminum Billet is ready to ship**



# 1X4 Engineering Model under test

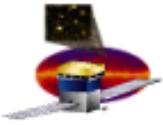




# Electronics –Status

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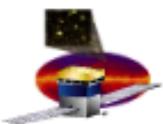
- **ASICS**
  - Final versions of ACD, CAL, and DAQ - delivery mid-September
  - Successful radiation tests of DAQ ASIC,s
- **Power Supplies**
  - Alternative power supply design being prototyped
  - Successful radiation tests of key components (DC/DC converters)
  - Power Distribution Unit board back from fabrication, loaded – EM in use by 1 Oct
- **Global Trigger, ACD, DAQ and Signal Distribution Unit (GASU)**
  - First breadboard complete
- **Tower Electronics Module (TEM) – a prototype of the final design in use by 1 Oct**
  - Engineering Models are in use at INFN, NRL, GSFC, UCSC, and SLAC
- **LAT Communication Board (LCB) EM in use**
- **Storage Interface Board EM in use**
- **Crate back-plane – ready to test**
- **EGSE TEM with ASICs – test-stands in fabrication**
  
- **Plan to complete requisitions for all flight-parts by mid-October**



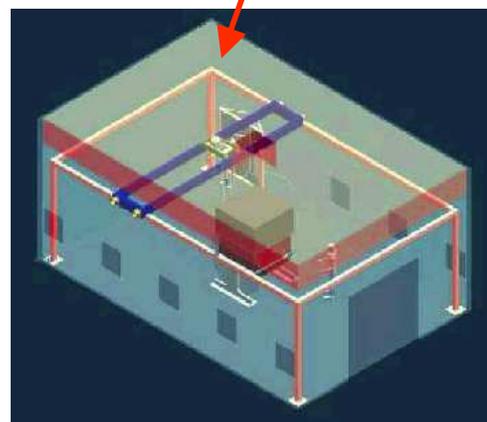
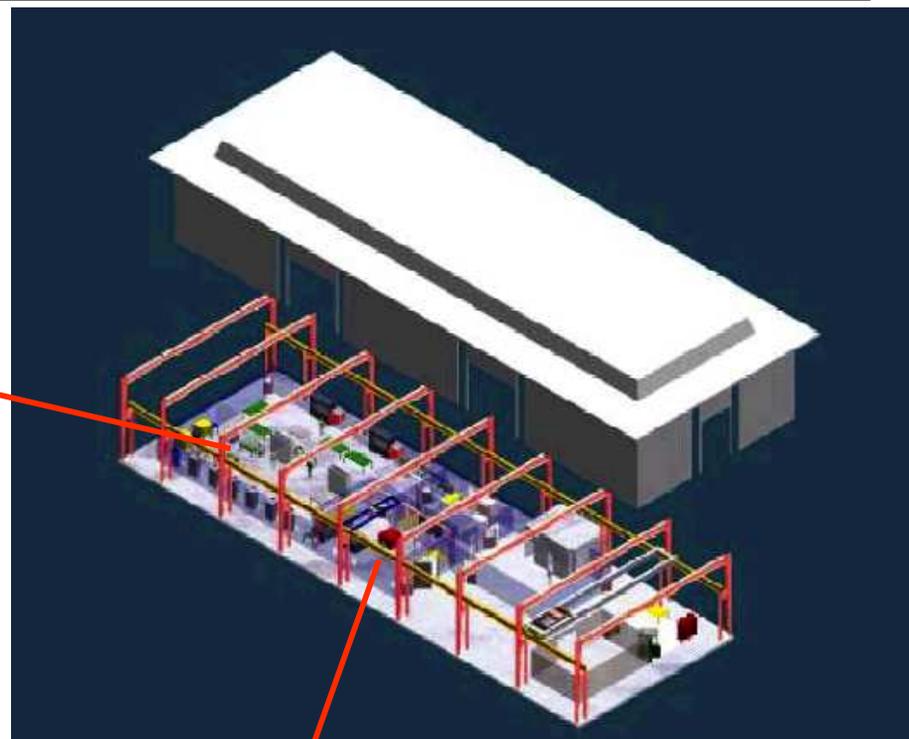
# Flight Software (FSW) - Status

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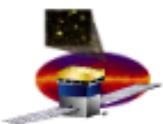
- **Excellent progress on filter (output data compression)**
- **First boot code committed to SUROM on RAD750 and tested**
- **Communication software packages begun**
- **EM1 (all SW to support TEM-based test-stand including monitoring, filtering) by 1 Oct**
- **Mini-tower test support through October**
- **Spectrum Astro Inc. spacecraft interface simulator received**



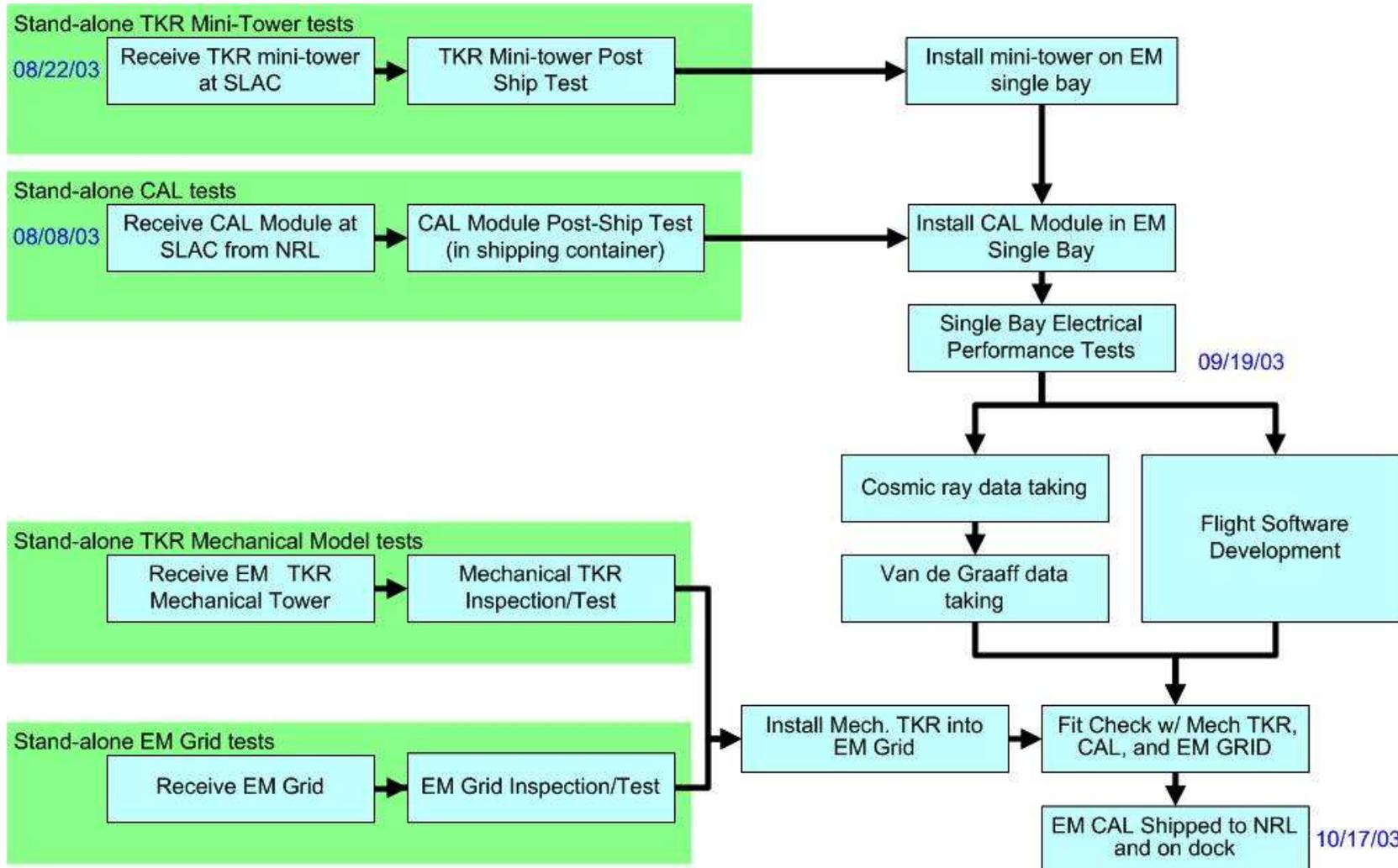
# LAT I&T

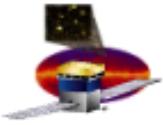


I&T Facility  
SLAC Bldg 33



# Engineering Model Test Flow





# Engineering Models

1 X 4 Grid

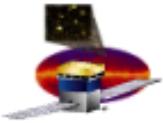


Calorimeter EM

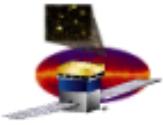


Tracker Minitower





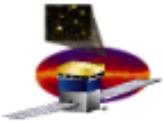
# Project Issues



# Project Issues

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1. **Transition to flight hardware production**
  - a. Closing design issues
  - b. Qualification testing
2. **Availability of critical skills**
  - a. Technically demanding design
  - b. Need both experts in space instruments and in particle detectors
3. **Aggressive cost and schedule plan**
  - a. 14 weeks of schedule float and 25 % cost contingency
4. **Communications**
  - a. Multi-disciplines
  - b. Work spread around the world
5. **End to end performance assessment**
  - a. Assuring that the instrument will meet science requirements
  - b. PI has established a task force



# Summary

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- **Rebaseline approved**
  - **Strong sponsor support**
  - **Cost and schedule is still tight**
- **LAT Design is mature**
  - **Instrument configuration is will understood**
  - **Many details need to be closed**
- **Transition to manufacture of flight hardware**
  - **Complete detailed design and analysis**
  - **Thorough testing**
    - **Subsystem modules tests**
    - **System tests**
    - **Engineering model tests**
    - **Hardware qualification testing**
- **Next 6 months critical to closing issues and beginning fabrication**